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High Performance Concrete

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Abstract: ***High performance concrete (HPC) has been defined as concrete that possesses high workability, high strength and high durability. American concrete institute (ACI) has defined HPC as a concrete in which certain characteristics are developed for a particular application and environment. Under the ACI definition durability is optional and this as led to a number of HPC structures, which should theoretically have had very long services lives, exhibiting durability associated distress early in their lives. ACI also define a high-strength concrete as concrete that has a specified compressive strength for design of 6000 psi (41 MPa) or greater. High performance concrete (HPC) is a concrete made with appropriate materials combined according to a selected mix design; properly mixed, transported, placed, consolidated and cured so that the resulting concrete will give excellent performance in the structure in which it is placed, in the environment to which it is exposed and with the loads to which it will be subjected for its design life. Mix proportions for high performance concrete (HPC) are influenced by many factors, including specified performance properties, locally available materials, local experience, personal preferences, and cost. With today's technology, there are many products available for using concrete to enhance its properties. The primary application for HPC have been structures requiring long service lives such as oil drilling platform, long span bridges and parking structures. HPC still requires good construction practice and good curing to deliver high performance.***

Keywords: Fly Ash, Super plasticizer, Compressive strength, Flexural strength, Split Tensile strength, HPC

1. Introduction

The American Concrete Institute (ACI) defines high-performance concrete as concrete meeting special combinations of performance and uniformity requirements that cannot always be achieved routinely when using conventional constituents and normal mixing, placing and curing practices. A high-performance concrete is something which demands much higher performance from concrete as compared to performance expected from routine concrete.

High Performance Concrete (HPC) is designed to provide several benefits in the construction of concrete structures as tabulated below:

Performance Benefits
- Ease of placement and consolidation without affecting strength
- long-term mechanical properties
- early high strength
- toughness
- volume stability
- longer life in severe environments

Cost & Other Benefits
- Less material
- Fewer beams
- Reduced maintenance
- Extended life cycle
- Aesthetics

A high-strength concrete is always a high-performance concrete, but a high-performance concrete is not always a high-strength concrete.

2. Materials Used

1) Cement
2) Fine Aggregate
3) Coarse Aggregate
4) Fly Ash
5) Super Plasticizer

3. Tests Conducted

3.1 Cement

Zuari 43 grade ordinary Portland cement is used for casting the elements. The following test are conducted
1) Fineness test
2) Standard consistency test
3) Initial setting time test
4) Final setting time test
5) Specific gravity test
6) Compressive strength test

3.2 Fine Aggregate

In this investigation fine aggregate is a naturaly available sand and it is free from dirt, dust and any organic matter. The fine aggregate used for the project was obtained from Krishna river.

The following tests were conducted on the sand:
1) Sieve analysis.
2) Bulking of sand by volume method.
3) iii.Specific gravity test.

3.3 Coarse Aggregates

In this investigation hard broken granite aggregate is used. The size aggregate is various from12 mm to 20 mm. The source the aggregates is Kavadpalli.

The following tests were conducted on the Coarse Aggregates

1) Specific Gravity
2) Fineness Modulus
3) Water Absorption
4) Aggregate Impact Test
5) Aggregate Crushing Test

3.4 Fly Ash

Finely divided residue that results from the combustion of ground or powdered coal." It is primarily the inorganic portion of the source coal in a particulate form. Fly ash is a very fine material consisting predominantly of small spheres of glass. The material once considered as a waste by product, finding difficulty to be disposed off, has now become a material of considerable value, when used in connection with concrete as an admixture.

The following fly ash tests are discussed in detail:
1) Moisture content,
2) Loss on ignition,
3) Silicon oxide content,
4) Alumina oxide content,
5) Calcium oxide content,
6) Chloride content,
7) Free calcium oxide content,
8) Total alkali oxides content,
9) Particle density determination (by Pycnometer bottle and Le-Chatlier Flask methods),
10) Fineness determination (by dry sieving, wet sieving, Blaine air permeability and laser methods)

The following tests for fly ash cement pastes, mortars, or concretes are outlined:
1) Soundness (expansion test),
2) water requirement (expressed as water content of test specimen divided by water content of control specimen to achieve equal specified consistencies)
3) Preparation and curing of specimens, determination of compressive strength (28 days).

3.5 Super Plasticizers

Plasticizers or water reducers, and super plasticizer or high range water reducers, are chemical admixtures that can be added to concrete mixtures to improve workability.

In order to produce stronger concrete, less water is added (without "starving" the mix), which makes the concrete mixture less workable and difficult to mix, necessitating the use of plasticizers, water reducers, super plasticizers or dispersants. Plasticizers are also often used when pozzolanic ash is added to concrete to improve strength. This method of mix proportioning is especially popular when producing high-strength concrete and fiber-reinforced concrete.

Adding 1-2% plasticizer per unit weight of cement is usually sufficient. Adding an excessive amount of plasticizer will result in excessive segregation of concrete and is not advisable. Depending on the particular chemical used, use of too much plasticizer may result in a retarding effect.

Table 1: Property of Super Plasticizers

Usage	High-range water reducing type super plasticizer
Classification	Polycarbixylate based super plasticizer
Appearance	Light brown liquid
Solid Content	Min. 40%
Viscosity (25ºC)	Max. 1000 cPS
Density	1.10 – 1.20 mg/l
Ph	4.0 – 7.5

3.6 Tests Conducted on HPC

3.6.1 Compressive Strength Test
3.6.2 Split Tensile Strength
3.6.3 Flexural Strength Test

4. Results

Table 2: Test Results on Cement

S.No	*Test Name*	*Result*		
1	sieve test	8 %		
2	standard consistency	29 %		
3	Initial setting time	52 min		
4	Final setting time	480 min		
5	Specific gravity test	3.15		
6	Compressive strength	3 days N/mm^2	7 days N/mm^2	28 days N/mm^2
		22.12	30.12	44.23

Table 3: Test Result on Fine Aggregate

S. No	*Test Name*	*Result*
1	Sieve analysis	Zone lll
2	Bulking of sand by volume method	12.5%
3	Specific gravity test	2.51
4	Relative density	45% (medium dense)

Table 4: Test Result on Coarse Aggregate

S.No	*Test Name*	*Result*
1	Fineness modulus	7.5
2	Specific gravity	2.83
3	Water absorption	2.1%
4	Crushing strength	22.43%
5	Impact test	28.12%

Table 5: Test Result on Compressive Strength

Specifications	*Compressive strength(N/mm^2)*		
Addition of fly ash	3 days	7 days	28 days
0%	26.68	29.77	45.77
10%	25.44	32.22	50.44
20%	24.58	34.60	52.33
30%	23.58	35.56	55.56
40%	22.98	28.25	44.23
Super plasticizers			
0%	26.68	29.77	45.77
0.50%	29.11	32.85	54.12
1%	30.01	35.98	54.85
1.50%	30.98	36.01	55.12
2%	25.12	28.12	44.85

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Test Result Explained by the Following Graphs.

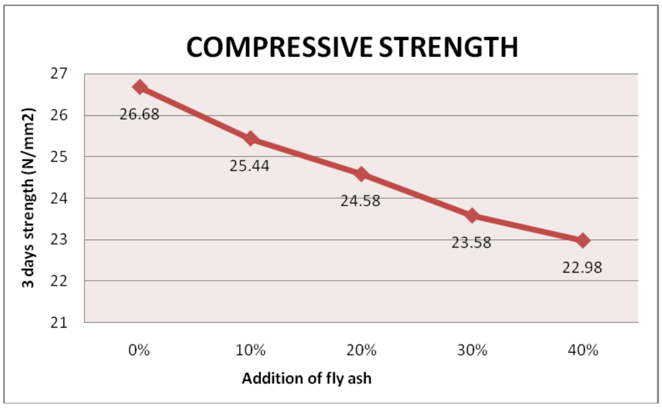

Figure 1: Graph Drawn between Compressive Strength Vs Addition of Fly Ash for 3 days

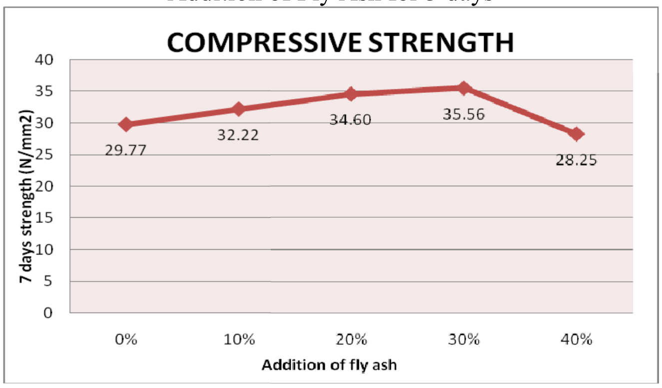

Figure 2: Graph Drawn between Compressive Strength Vs Addition of Fly Ash for 7 days

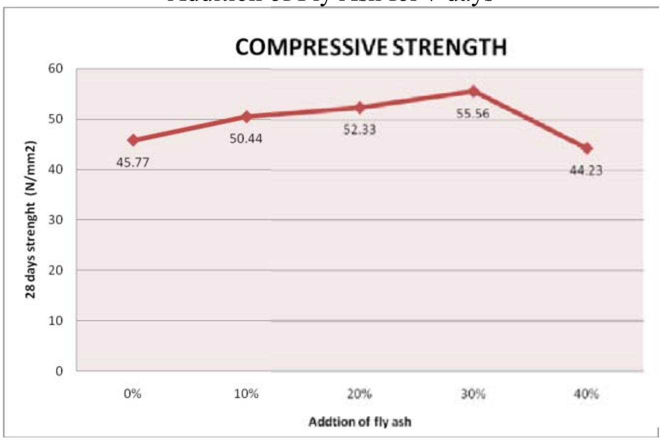

Figure 3: Graph Drawn between Compressive Strength Vs Addition of Fly Ash for 28 days

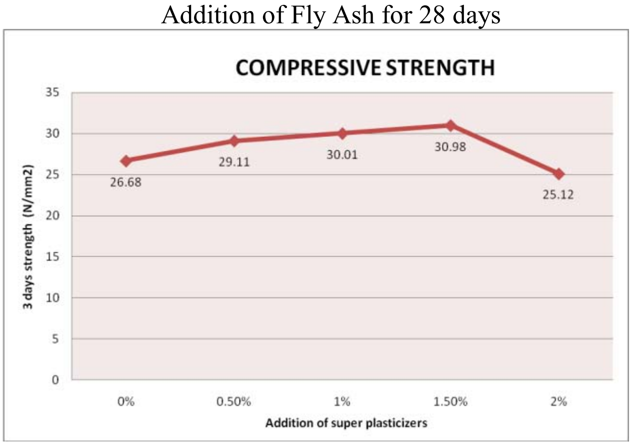

Figure 4: Graph Drawn between Compressive Strength Vs Addition of Super Plasticizer for 3 days

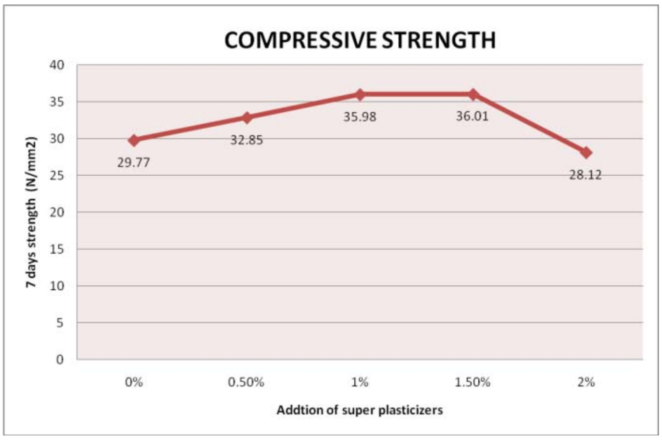

Figure 5: Graph Drawn between Compressive Strength Vs Addition of Super Plasticizer for 7 days

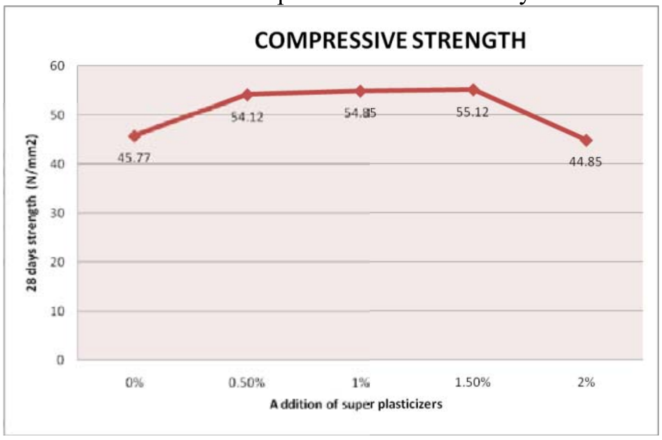

Figure 6: Graph Drawn between Compressive Strength Vs Addition of Super Plasticizer for 28 days

Table 6: Test Result on Split Tensile Strength

Specifications	*Split tensile strength (N/mm^2)*		
Addition of fly ash	3 days	7 days	28 days
0%	2.26	2.50	3.00
10%	2.40	2.68	3.51
20%	2.60	2.90	3.53
30%	2.70	3.08	3.70
40%	2.16	2.55	2.8
Super plasticizers			
0%	2.26	2.67	2.9
0.50%	2.70	3.20	3.54
1.0%	2.87	3.35	3.68
1.50%	2.96	3.45	3.72
2.0%	2.22	2.54	2.85

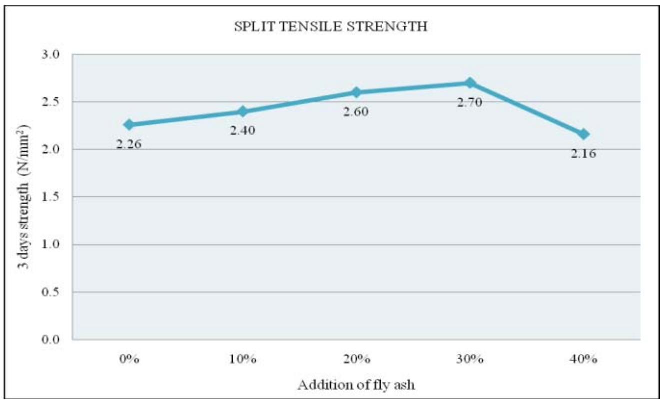

Figure 7: Graphs Drawn between Split Tensile Strength Vs Addition of Fly Ash for 3 days

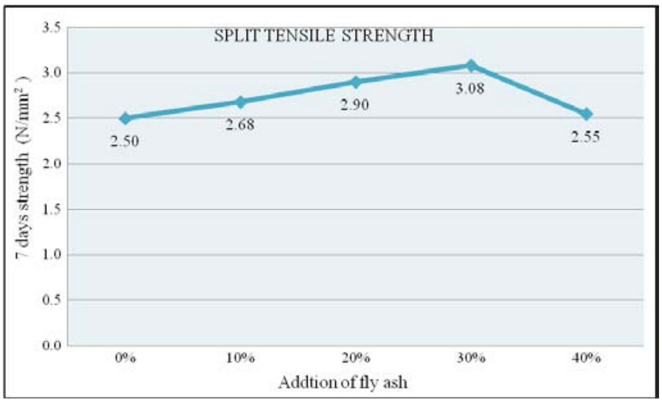

Figure 8: Graphs Drawn between Split Tensile Strength Vs Addition of Fly Ash for 7 days

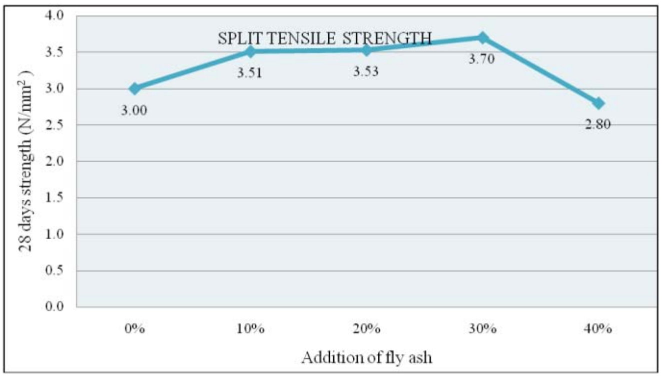

Figure 9: Graphs Drawn between Split Tensile Strength Vs Addition of Fly Ash for 28 days

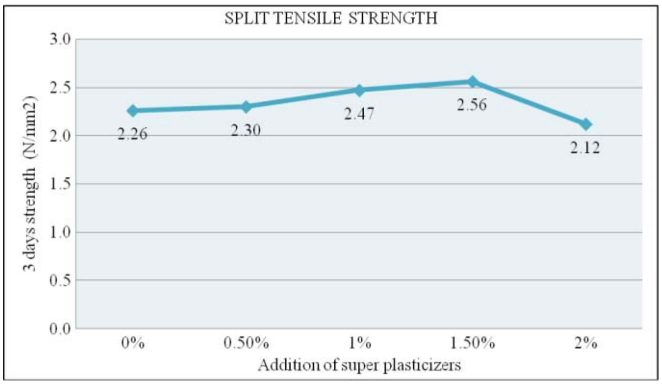

Figure 10: Graphs Drawn between Split Tensile Strength Vs Addition of Super Plasticizer for 3 days

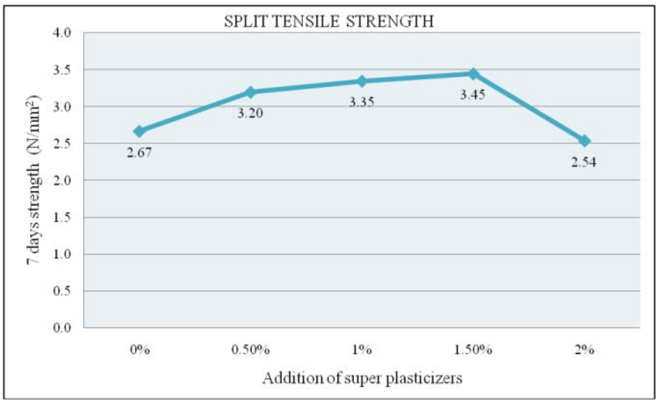

Figure 11: Graphs Drawn between Split Tensile Strength Vs Addition of Super Plasticizer for 7 days

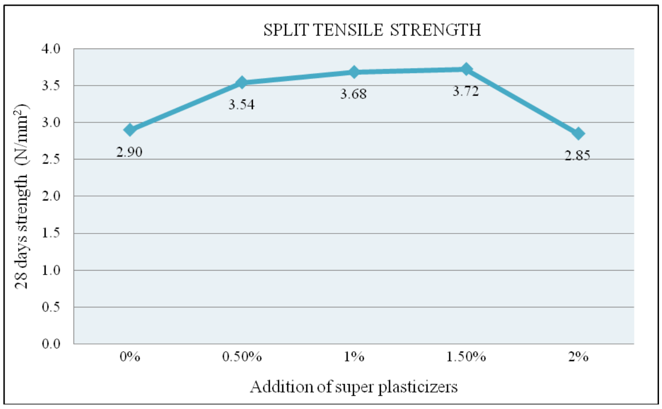

Figure 12: Graphs Drawn between Split Tensile Strength Vs Addition of Super Plasticizer for 28 days

Table 7: Test Results on Flexural Strength

Specifications	Flexure strength (N/mm²)		
Addition of fly ash	3 days	7 days	28 days
0%	3.12	5.45	7.05
10%	4.25	5.7	7.42
20%	5.12	6	7.92
30%	5.25	6.2	8.05
40%	3.02	5.35	6.95
Super plasticizers			
0%	3.12	5.45	7.05
0.50%	4.62	5.90	7.12
1%	4.82	5.98	7.35
1.50%	4.91	6.01	7.48
2%	3.00	5.32	6.95

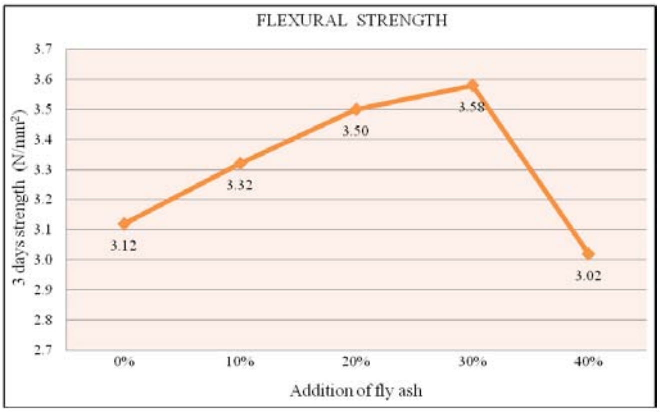

Figure 13: Graphs drawn between Flexural strength vs Addition of fly ash for 3 days

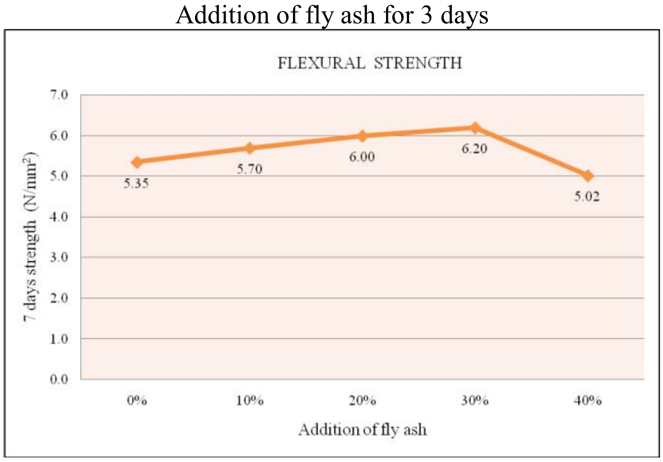

Figure 14: Graphs drawn between Flexural strength vs Addition of fly ash for 7 days

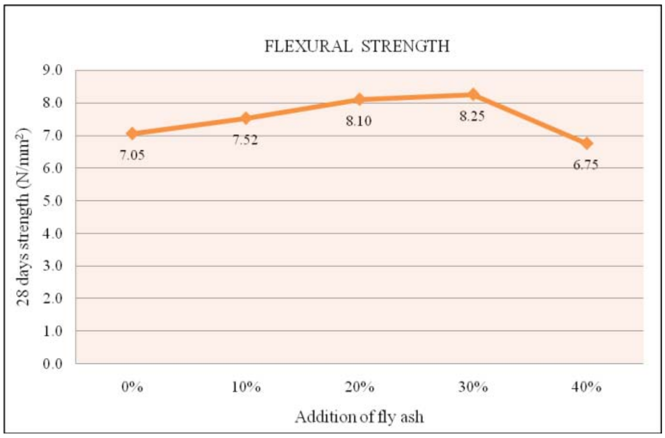

Figure 15: Graphs drawn between Flexural strength vs Addition of fly ash for 28 days

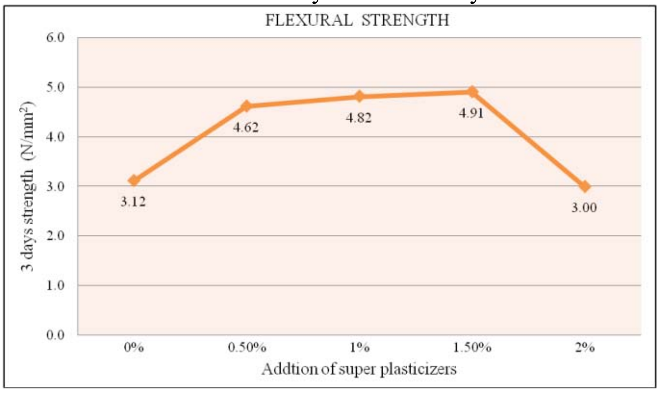

Figure 16: Graphs drawn between Flexural strength vs Addition of Super Plastisizer for 3 days

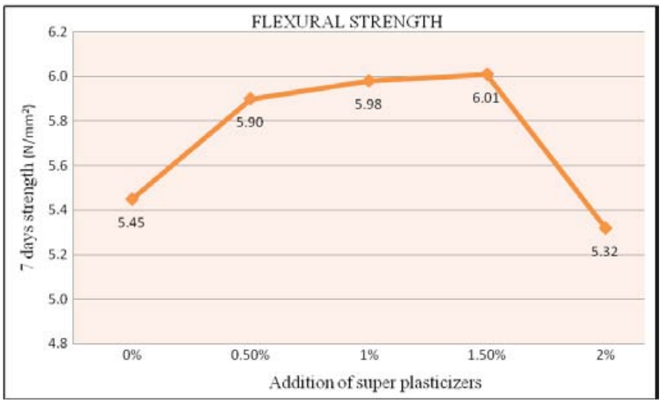

Figure 17: Graphs drawn between Flexural strength vs Addition of Super Plastisizer for 7 days

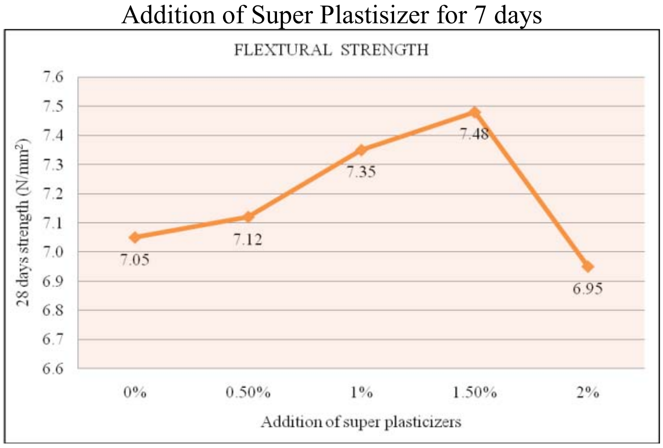

Figure 18: Graphs drawn between Flexural strength vs Addition of Super Plastisizer for 28 days

5. Conclusions

1) Fly ash is added at different proportions namely 0%, 10%, 20%, 30% and 40%.
2) For 43 grade cement with M40 mix, by adding up to 30% of fly ash to the cement, the strength is increased and by adding 40% of fly ash the strength is decreasing.
3) The test results show that on addition of 30% of fly ash to cement it has gained maximum strength at 28 days period but the rate of strength gain compared to ordinary Portland cement concrete OPCC is at slower rate at initial days.
4) The compressive strength increased by 22.44%, split tensile strength increased by18.37% and flexural strength increased by 16.18% when compare to normal concrete.
5) By use of fly ash as admixture, the cost of construction is also considerably reduced.
6) Non-biodegradable fly ash is effectively utilized in H.P.C, so it reduces the disposal problem of fly ash.
7) For 43 grade cement with M40 mix, by adding 0%, 0.5%, 1.0%, 1.5% of super plasticizer to the mix prepared the strength is slightly increased and at adding 2.0% of plasticizer to the mix prepared the strength will slightly decreased.
8) The test results show that on addition of 1.5% of super plasticizers to concrete it has gained maximum strength at 28 days period
9) The compressive strength increased by 20.22%, split tensile strength increased by16.32% and flexural strength increased by 13.46% when compare to normal concrete.
10) Super plasticizer may not increase the strength of concrete directly. But it helps in reducing the w/c ratio. Which in turn result in the increase of strength of concrete due to reduction of w/c ratio.
11) It is concluded that when compare to super plasticizer, fly ash gives more desirable properties to concrete and eco friendly.

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